Determination Of The Shelf Life Of Tamban Fish *Choux Pastry* (*Sardinella Lemuru*) Using The *Accelerated Shelf Life Testing* (Aslt) Method

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Abstract. *Choux pastry* is a light snack characterized by its small size, softness, volume, and yellow-brown color. The choux pastry product has been diversified with the addition of tamban fish. The fat content and moisture content in the tamban fish *choux pastry* are 37.77% fat and 8.41% moisture, respectively. Finding the ideal shelf life for tamban fish *choux pastry* (*Sardinella lemuru*) is the aim of this investigation. The Arrhenius model and the ASLT method are used to calculate the tamban fish choux pastry's shelf life. The product is kept in three different temperature ranges: 30˚, 40˚, and 50˚C, with moisture content tests conducted every 10 days on days 0, 10, 20, and 30 of storage. The total plate count (TPC) test results show the highest value on day 30 at 30˚C storage temperature, which is 2.5 x 10^3 CFU/ml. The hedonic test results show that the color of the choux pastry has an average score 2.34-2.81, aroma has an average score of 1.93-2.68, and texture has an average score of 2.28-2.76. Shelf determination life is based on critical parameters, specifically the TPC and hedonic. The results show that the tamban fish *choux pastry* 33 days at 30˚C, 35 days at 40˚C, and 33 days at 50˚C are the product's shelf lives.

1 Introduction

In Indonesia, *choux pastry* is known as a dry cake with characteristics of being light, small in size, soft, voluminous, and having a light brown to brownish-yellow color [1]. Generally, *choux pastry* uses wheat flour as its main ingredient, but diversification has been carried out by adding other ingredients such as fish meat [2], a combination of seaweed (Kappaphycus alvarezii) and fish meat (*Sardnella lemuru*), and seaweed (*Kappaphycus alvarezii*) [3]. These three *choux pastry* products have different fat and water content. However, the highest fat and water content were obtained from the fish meat choux pastry, with a fat content of 37.77% and a water content of 8.41% [2].

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High fat content in the product can cause stickiness, leading to a decrease in product quality. In addition, water content can serve as a medium for microbial growth, including pathogenic microbes, thus reducing product quality [4]. Therefore, further research is needed to provide information on product shelf life and the point of change that makes consumers unacceptable of the product.

One of the most crucial pieces of information to understand a product's resistance to storage is its shelf life. High fat content can cause stickiness in the product [5]. Furthermore, one more element that influences how long food products last on the shelf is temperature. Various chemical substances react more quickly at higher storage temperatures [6]. Therefore, storage temperature should be considered to determine the product's resistance during storage [7].

Shelf life determination is categorized into two types, Among these is the *Accelerated Shelf Life Testing* (ASLT) technique. ASLT is a widely used technique for estimating the shelf life of products with limited shelf lives, accelerating food spoilage, and reducing costs. This study assesses shelf life using the *Accelerated Shelf Life Testing* (ASLT) method. The ASLT method is popular because it can quickly ascertain a product's shelf life, accelerating the degradation of food materials, and saying costs. When hazardous chemical elements cause food products to lose quality, the Arrhenius model of ASLT is typically utilized [8]. Hasany et al. (2017) reported that fruit nori has a shelf life of 31 days, 13 hours, and 48 minutes at 25ºC, whereas Harjan et al. (2018) reported that smoked roa fish (*Hemiraphus* sp.) has a shelf life of 2 months and 8 days at 30ºC, are two instances of fisheries goods that were assessed utilizing the Arrhenius model and the ASLT method [9,10].

Further research on the shelf life of using the Arrhenius model of ASLT *choux pastry* can be carried out in light of the background information provided, as it can expedite the product degradation process, thus requiring a relatively short amount of time.

2 Method

2.1 Material

The tamban fish (*Sardinella lemuru*) serves as the primary raw material in this study. The additional ingredients for making *choux pastry* include margarine, high-protein flour, eggs, baking powder, and water.

2.2 Equipment

The equipment used for analysis includes an incubator, autoclave, hot plate, test tubes, petri dishes, graduated cylinders, beakers, and a *colony counter*.

2.3 Steps in Making Choux Pastry with the Addition of Tamban Fish (*Sardinella lemuru*)

Tamban fish is purchased at Bintan Center market, then washed thoroughly under running water and the entrails are removed. After that, the fish is filleted, and the fish flesh is blended until smooth.

To make the *choux pastry*, mix the additional ingredients, which include margarine, water, and high-protein flour. Then, add baking powder and eggs to the mixture, followed by the finely blended tamban fish. The dough is shaped using molds and baked twice, For 20 minutes at 200 ºC, then for another 30 minutes at 180 ºC. The recipe for creating *choux pastry* with tamban fish is shown in Table 1.

Table 1. Formulation for Making *Choux Pastry* with the Addition of Tamban Fish

Ingredients	Treatment (%)
	IK3
Tamban Fish	25
Wheat Flour	20
Eggs	25
Margarine	20
Water	9
Baking powder	1
Total	100

2.4 Total Plate Count (TPC)

Total Plate Count (TPC) calculation using SNI 2332.3:2015 as a guide. 25 grams of the material should be weighed and put in a beaker with 225 milliliters of distilled water. Take 1 ml of the suspension using a sterile pipette, and place it into 9 ml of physiological solution, homogenizing it to produce a 10^{-1} dilution. Then, for the 10^{-2}, 10^{-3}, and 10^{-4} dilutions, take 1 ml from each of the above dilutions using a pipette and pour it into a sterile petri dish, adding 15 ml of PCA to each petri dish containing the sample solution. Place the dishes in an incubator, then the total bacterial count in the product can be calculated. Bacterial growth is observed after the sample is incubated in agar media at mesophilic temperatures (35°C ± 1°C), with checks performed after 24 and 48 hours. The bacteria grown on the agar medium will multiply by forming colonies, which can be counted directly using a *colony counter*.

2.5 Organoleptic Test

Organoleptic testing is a type of sensory evaluation where the main means of gauging a product's acceptability is through human senses. An organoleptic test is a hedonic test that looks at a product's color, texture, and fragrance changes. This hedonic test uses 80 untrained panelists, with a preference rating based on a scale of 1 to 3. The scoring system is 1 (dislike), 2 (neutral), and 3 (like) (Sari *et al*., 2021).

2.6 Determination of Shelf Life for *Choux Pastry* with Tamban Fish (*Sardinella lemuru*)

The *Accelerated Shelf Life Test* (ASLT) involves exposing the food product to three different extreme storage temperatures in an oven using the Arrhenius model. Every ten days, the rate of quality degradation for each parameter is determined using an Arrhenius plot, with the In k value on the y-axis following a zero-order reaction, and the x-axis representing the temperatures of each storage condition (30 ºC, 40 ºC, and 50 ºC).

Next, the regression equation of the graph for each storage temperature is used to get the constant quality degradation value every ten days. The K values for each storage temperature are computed after the In k values have been determined. The slope of the linear regression derived from the three storage temperatures is indicated by the K value. Next, the slopes from the Arrhenius plot are calculated to yield the K0 and Ea/R values. The following formula can be used to determine the shelf life based on the zero-orde reaction:

$$t = \frac{(A0 - At)}{k} \quad (1)$$

Explanation:
t = predicted shelf life
A0 = initial quality value
At = remaining product quality value after time t
K_0 = constant

In the meanwhile, the shelf life can be calculated using the following formula if a first-order reaction occurs:

$$t = \frac{(\ln A0 - \ln At)}{k} \quad (2)$$

2.7 Data Analysis

The data analysis in this research consists of three different storage temperatures, namely 30 ºC, 40 ºC, and 50 ºC, with three repetitions. In the hedonic testing, the Kruskal-Wallis method is used, and if significant effects are observed, the Mann-Whitney follow-up test is conducted. Other analytical calculations are performed using Microsoft Excel 2010. To estimate the product's shelf life, the observation data from the hedonic test and total plate count were examined using linear regression techniques with the Arrhenius method. The formula for an Arrhenius model is:

$$K = k_0 \, e^{-E/RT} \quad (1)$$

Explanation:
K = degradation rate constant
K_0 = constant
E = activation energy
R = gas constant 1,986 kal/mol

3 Results and Discussion

3.1 Total Plate Count (TPC)

According to SNI 2332.3:2015, which specifies how to calculate the Total Plate Count (TPC) in fisheries products, the number of bacterial colonies on a plate should range between 25 and 250 colonies [11]. The number of bacteria that grow during testing serves as an indicator of the product's suitability. Image 1 shows the outcomes of the Total Plate Count (TPC) tests conducted at 35°C for incubation.

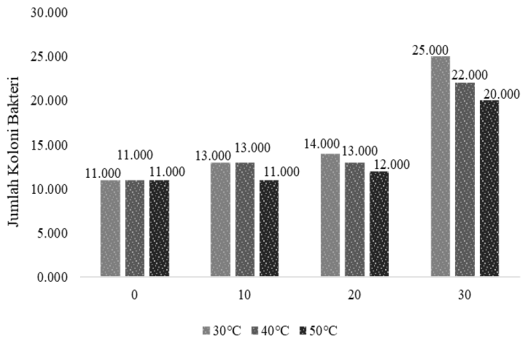

Fig. 1. The Histogram of Total Plate Count

The test values from day 0 to 30 showed colony numbers with an average of 11,000-25,000 colonies. On day 30, with a storage temperature of 30°C, the highest Total Plate Count was observed due to the optimal and faster growth of mesophilic bacteria. Mesophilic bacteria can grow at temperatures between 20-45°C (Muslimin et al. 2016). Temperature is one of the many factors that normally affects the reduction of germs in food goods. If the temperature increases, it can inhibit the growth of most bacteria, causing many bacteria to not survive (Alyani et al. 2016). In contrast to SNI 2332.3:2015, This details the process for determining the Total Plate Count (TPC) in fisheries products, the maximum limit is 5 x 10^{-5} or a colony count not less than 25 and not exceeding 250 colonies [11]. Thus, the Total Plate Count (TPC) test, which began from 10^{-2}, 10^{-3}, and 10^{-4} dilutions with observations on days 0, 10, 20, and 30 on tamban fish (*Sardinella lemuru*) *choux pastry*, meets the standard TPC calculation limits, making it safe and suitable for consumption.

3.2 Hedonic Test

This test involved 80 untrained panelists, with the same panelists used for observations every 10 days. The panelists in this study were aged between 10 and 50 years, consisting of both males and females. The test parameters included attributes of color, aroma, and texture of the tamban fish (*Sardinella lemuru*) *choux pastry* product.

3.2.1 Color

Color plays a key role as the main determining factor before consumers assess other sensory aspects such as aroma, taste, and texture (Negara et al. 2016). Image 2 displays the findings of the hedonic test for the hue of the tamban fish (*Sardinella lemuru*) choux pastry.

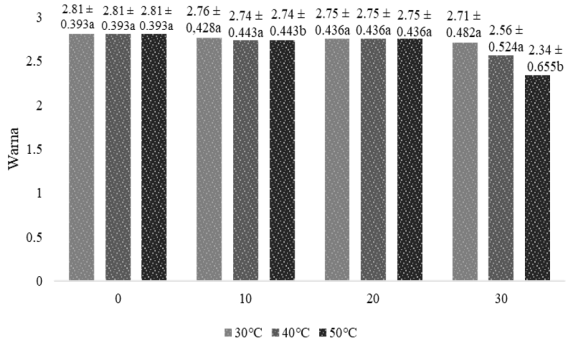

Fig. 2. Histogram of Texture Values for Tamban Fish (*Sardinella lemuru*) *Choux Pastry*

The color of the *choux pastry* has an average score of 2.34–2.81. In the *Kruskal-Wallis* non-parametric test, the color of the tamban fish *choux pastry* on day 0 and day 20 with storage temperatures of 30ºC, 40ºC, and 50ºC yielded insignificant results of 1.000 on day 0 and 0.238 on day 20 ($P>0.05$), meaning there is no difference. However, on days 10 and 30, A significant difference was indicated by the significant result of 0.000 ($P<0.05$) obtained from the Kruskal-Wallis non-parametric test. Next, a post-hoc Mann-Whitney analysis was carried out. Day 30 saw a distinct color shift brought on by non-enzymatic browning, like the Maillard process that occurs during baking.

3.2.2 Aroma

One of the sensory factors that is used to assess a product's quality is its aroma. Image 3 displays the findings of the hedonic test conducted to determine the aroma of tamban fish (*Sardinella lemuru*) *choux pastry*.

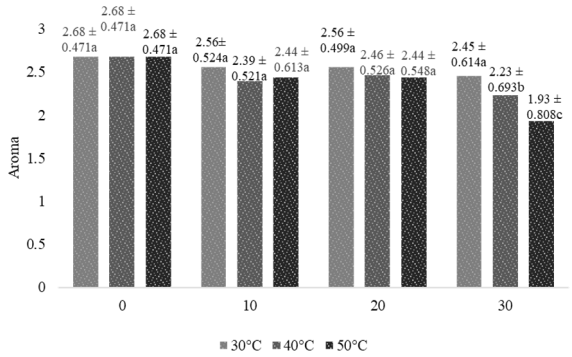

Fig. 3. Histogram of Aroma Values for Tamban Fish (*Sardinella lemuru*) *Choux Pastry*

The aroma of tamban fish *choux pastry* has an average score of 1.93–2.68. The high storage temperature of the tamban fish choux pastry causes an undesirable or altered aroma. The rate of evaporation increases with temperature (Aggraini and Yunianta, 2015). In the *Kruskal-Wallis* non-parametric test, the aroma of the tamban fish choux pastry on days 0, 10, and 20 yielded insignificant results (P>0.05), meaning there is no difference. On the other hand, The Mann-Whitney post-hoc test was employed when a significant result of 0.000 (P<0.05) was achieved on day 30, signifying a significant difference.The Mann-Whitney post-hoc test was employed when a significant result of 0.000 (P<0.05) was achieved on day 30, signifying a significant difference.

3.2.3 Texture

A crispy texture will affect the tamban fish (*Sardinella lemuru*) *choux pastry*; the higher the temperature applied, the harder the texture will become. Image 4 displays the findings of the hedonic test conducted to determine the texture of tamban fish *choux pastry*.

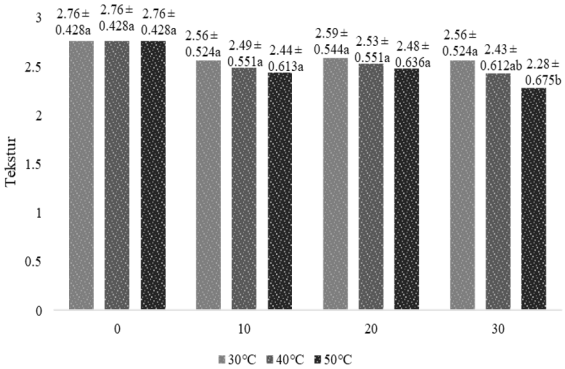

Fig. 4. Histogram of Texture Values for Tamban Fish (*Sardinella lemuru*) *Choux Pastry*

The texture of tamban fish *choux pastry* has an average score of 2.28–2.76. In the *Kruskal-Wallis* non-parametric test, the texture of tamban fish *choux pastry* on days 0, 10, and 20 yielded insignificant results (P>0.05), meaning there is no difference. However, using the Mann-Whitney post-hoc test, a significant difference was discovered on day 30, producing a significant result of 0.000 (P<0.05). The panelists' preference for the product that was kept at a high temperature decreased as a result of the texture hedonic test results. This is due to increased water evaporation and a higher concentration of total dissolved solids.

3.3 Shelf Life Determination

The Accelerated Shelf Life Test (ASLT) technique is widely used to determine the shelf life of products that are vulnerable to chemical processes like oxidation, which is based on the Arrhenius model, protein denaturation, the Maillard reaction, and others. Changes in product quality metrics and storage temperature can be correlated since rising temperatures generally quicken chemical reactions. In this study, the critical parameters used were moisture content. Moisture content was selected because dry foods can spoil if they absorb excessive moisture[12].

To find the shelf life of the tamban fish (Sardinella lemuru) choux pastry, the Arrhenius model in the ASLT method was employed. Making a graph of quality changes and computing the linear regression equation derived from the observational data of the Total Plate Count (TPC) parameter and the hedonic test are the first steps in this approach. Furthermore, the Hastened Shelf Life Test (ASLT) approach can be used to anticipate the hastened deterioration of items subjected to high or harsh temperatures. applying the zero-orde reaction Arrhenius equation, as illustrated in Images 5, 6, 7, and 8.

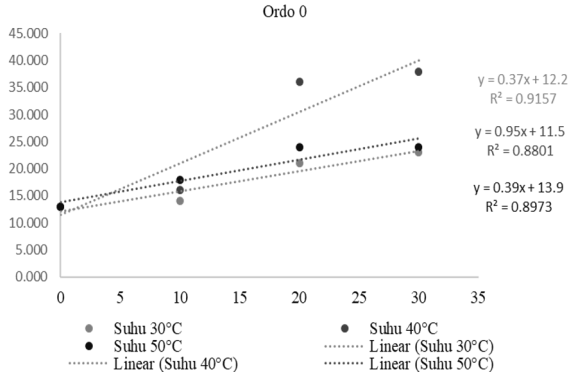

Fig. 5. Graph of the TPC Values in Zero Order Linear Regression Equatio

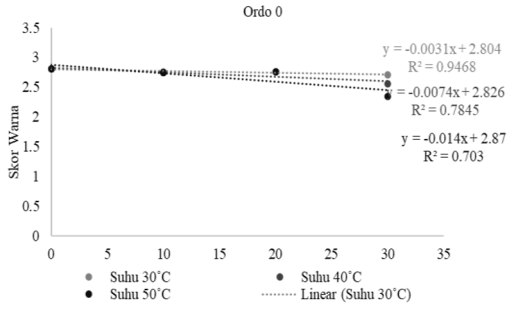

Fig. 6. Linear Regression Equation Graph of Color Values at First Orde

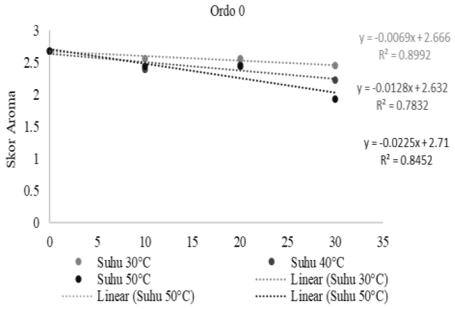

Fig. 7. An illustration of the Linear Regression Equation in Zero Order for Aroma Values

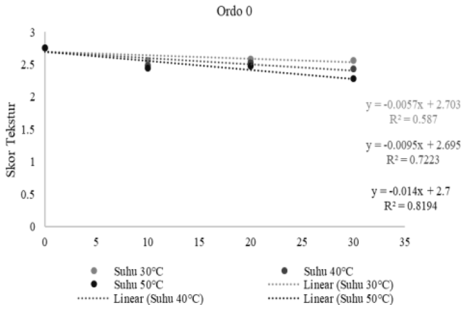

Fig. 8. Graph of the Texture Values in Zero Order Linear Regression Equation

The slope value (k) obtained from the TPC and hedonic test graph of each linear regression equation is then tabulated into Table 2.

Table 2. Slope and In Slope Values at Three Storage Temperatures for Moisture Content Test

Temperatur		1/T or 1/K	Ordo 0		
˚C	K		R^2	Slope (b)	In K
TPC					
30	303	0.00330	0.8467	0.3100	1.36340
40	313	0.00319	0.7485	0.3300	1.39100
50	323	0.00310	0.6877	0.2800	1.32310
Color					
30	303	0.00330	0.9468	0.0031	-5.77635
40	313	0.00319	0.7845	0.0074	-4.90628
50	323	0.00310	0.7030	0.014	-4.26870
Aroma					
30	303	0.00330	0.8992	0.0069	-4.97623
40	313	0.00319	0.7832	0.0128	-4.35831
50	323	0.00310	0.8452	0.0225	-3.79424
Texture					
30	303	0.00330	0.587	0.0057	-5.16729
40	313	0.00319	0.7223	0.0095	-4.65646
50	323	0.00310	0.8194	0.014	-2.26870

Next, using the Arrhenius method, a graph was made to show how the product's rate of quality degradation related to its storage temperature. The zero-order hedonic test graph (color, texture, and scent) and TPC parameter between ln k and storage temperature 1/T are shown in Table 3.

Table 3. Relationship of ln slope (K) with 1/T

Parameters	Relationship of ln slope (K) with 1/T	R2
	Ordo 0	Ordo 0
TPC	y = 192.15x + 0.7449	0.3312
Color	y = -7387.2x + 18,634	0.9951
Aroma	y = -5784.9x + 14.118	0.9999
Tekstur	y = -4805.9x + 9.7148	0.9963

The linear regression equation is then ln ko - E/R using the ln k approach, where E/R is the slope, E is the activation energy, ln ko is the intercept, and R is the gas constant (1.986 cal/mol). The activation energy for the TPC and hedonic test settings is shown in Table 4.

Table 4. Activation Energy

Parameters		Activation Energy (Kal/mol)
	Temperatur˚C	Ordo 0
TPC	30	3816
	40	
	50	
Warna	30	1467
	40	
	50	
Aroma	30	1148
	40	
	50	
Texture	30	8742
	40	
	50	

The linear regression equation of the parameter with the lowest activation energy value based on Table 4 is used to calculate the shelf life, or fragrance parameter, which has a value of 1148 cal/mol. Therefore, the critical quality of this product is aroma, as a lower activation energy value indicates that a reaction will occur more quickly, meaning it will more rapidly affect the deterioration of the tamban fish (*Sardinella lemuru*) *choux pastry*. The shelf life calculation of tamban fish choux pastry follows zero-order kinetics for the aroma parameter, as shown in Table 5.

Table 5. Shelf Life of Tamban Fish (*Sardinella lemuru*) *Choux Pastry*

Ordo 1					
Parameters	Temperatur (˚C)	1/T	In k	K	Hari
Aroma	30	0.00330	-4.97623	0.00691	33
	40	0.00319	-4.35831	0.01272	35
	50	0.00310	-3.79424	0.02255	33

Based on the research results in Table 5, Differences in storage temperature will affect the aroma of tamban fish (Sardinella lemuru) choux pastry. The product has a different shelf life at each storage temperature: it lasts 33 days at 30˚C, 35 days at 40˚C, and 33 days at 50˚C. Storing the product at higher temperatures affects its aroma, and the longer the

storage period, the more the aroma diminishes due to the hydrolysis of fats by water, resulting in an undesirable odor.

4 Conclusion

Using the Accelerated Shelf Life Testing (ASLT) approach, the Arrhenius model was utilized to determine the tamban fish (Sardinella lemuru) choux pastry's shelf life. Changes in storage temperature affect how long a product lasts, according to the findings. as evidenced by the regression equation for activation energy and the coefficient of determination. Differences in storage temperature will affect the aroma of tamban fish (Sardinella lemuru) choux pastry. The product has a different shelf life at each storage temperature: it lasts 33 days at 30˚C, 35 days at 40˚C, and 33 days at 50˚C. Storing the product at higher temperatures affects its aroma, and the longer the storage period, the more the aroma diminishes due to the hydrolysis of fats by water, resulting in an undesirable odor.

References

1. Imra, Gusriani, M. Akhmadi, and B. Cahyani, Reni Tri Cahyani1Dan, J. Perikan. Dan Kelaut. **13**, 169 (2023)
2. W. J. P. Ilahi, R. M. S. Putri, and S. N. Amrizal, Pengaruh Penambahan Ikan Tamban (Sardinella Lemuru) Terhadap Pembuatan Choux Pastry, Universitas Maritim Raja Ali Haji, 2023
3. S. N. Aina, R. M. S. Putri, and S. N. Amrizal, Diversifikasi Olahan Rumput Laut (Kappapycus Alvarezii) Terhadap Pembuatan Choux Pastry, Universitas Maritim Raja Ali Haji, 2024
4. H. Harris and D. M. Fadli, J. Saintek Perikan. **9**, 53 (2014)
5. E. R. Asih and Y. Arsil, J. Pengolah. Has. Perikan. Indones. **25**, 107 (2022)
6. A. D. Gea, Jumsurizal, and A. F. Ilhamdy, Penentuan Umur Simpan Epok Epok Ikan Tongkol (Euthynnus Sp) Di CV. Citra Sari Tanjungpinang Kepualauan Riau, Universitas Maritim Raja Ali Haji, 2023
7. Y. C. B. Karo, R. Nopianti, and S. D. Lestari, J. FishtecH **6**, 80 (2017)
8. V. Nuraini and Y. A. Widanti, J. Agroteknologi **14**, 189 (2020)
9. M. R. Hasany, E. Afrianto, and R. I. Pratama, J. Perikan. Dan Ilmu Kelaut. **8**, 48 (2017)
10. I. Harjan, Techno J. Penelit. **7**, 105 (2018)
11. BSN, (2015)
12. R. M. S. Putri, N. Nurjanah, and K. Tarman, Marinade **1**, 45 (2018)